



# **132kV Steel Pole Transmission Lines**

## **Preliminary Technical Specification for NeSTS 132 kV Single Circuit**

**Issue 5**

**March 2020**

## REVISION HISTORY

Prep	Chkd	Appr	Issue	Date	Comments:
JS	MDL	TS	1	14/03/2019	First issue for comment
MDL	TS	TS	2	1/5/2019	Manufacturing tolerances annex added.
MDL	TS	TS	3	20/6/2019	Clause 11.13 added (uplift); Note 3) to Table 8 added; Table 14 added.
TS	TS	TS	4	4/11/19	Conductor lateral offset requirement removed (7.7)
TS				2/3/20	Added S460 option and metallisation clauses.

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## Foreword

This Preliminary Technical Specification (PTS) is published by the NeSTS Project. It sets out the functional requirements and design bases for the new suite of 132kV single circuit (SC), steel, monopole supports. The development process is not complete at the time of publication as further development and verification work is planned, including technical reviews and physical testing of supports.

The intention is that the NeSTS support series will be suitable for application anywhere within Great Britain, subject to the limits of application stated herein.

The design parameters adopted for the development of this issue of the PTS correspond to the 132kV SC suite. Subsequent issues may incorporate details for other application duties. The upper limits of the adopted design parameters are considered to correspond to the environmental conditions encountered on a wide range of the network in Great Britain.

## 1. Scope

This PTS is applicable to new overhead lines constructed with NeSTS 132kV SC steel pole supports.

The extent of the application of BS EN 50341-1 (Part 1) in the United Kingdom, is defined in BS EN 50341-2-9:2017 (Part 2-9).

Reference should be made to Part 1, Part 2-9, and the Project specification for details of design, manufacture, installation and testing of all other components for the OHL, including the fabrication and installation of the supports.

Only specific support types and ranges of extensions have been analysed for compliance with Part 1 and Part 2-9, based on a defined set of generic loading conditions, as set out in the main body of text and design load schedules in Annex B.

Where loading conditions, support types or extensions are outside the parameters quoted, the users of this PTS are responsible for undertaking their own specific checks.



## 2. Normative references

The following referenced documents, in whole or part, are indispensable for the application of this PTS. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

### 2.1. Standards publications

BS EN 1992 and NNAs to BS EN 1992  
Design of concrete structures

BS EN 1993 and NNAs to BS EN 1993  
Design of steel structures

BS EN 1997 and NNAs to BS EN 1997  
Geotechnical design

BS EN 10025  
Hot rolled products of structural steels

BS EN 50341-1:2012  
Overhead electrical lines exceeding AC 1 kV.  
General requirements. Common specifications

BS EN 50341-2-9:2017  
Overhead electrical lines exceeding AC 1 kV.  
National Normative Aspects (NNA) for Great Britain and Northern Ireland

ASCE 48-11: 2012  
Design of Steel Transmission Pole Structures

### 2.2. Other publications

ENA TS 43-125: Issue 2:2017  
Design guide and technical specification for overhead lines above 45kV<sup>1</sup>

Electricity Safety, Quality and Continuity Regulations 2002 (and Amendments)

National Grid Company Linesman's Manual M1,  
132 kV, 275 kV and 400 kV Overhead lines, ('Dead Line' Working)<sup>2</sup>

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<sup>1</sup> The foreword to ENA TS 43-125 Issue 2 implies that it applies to lattice steel supports in particular, and not to pole supports, however, useful guidance is given for overhead lines in general. Reference has been made to ENA TS 43-125 for certain aspects of the design.

<sup>2</sup> Note Manual M1 revision to be confirmed.

### **3. Terms and definitions**

For the purposes of this document, the following terms and definitions apply.

#### **3.1. Deterministic design basis**

Consideration of the effects of fixed sets of loadings and weather conditions on the overhead line to ensure that the stress in each tower component is limited to be within the yield stress or ultimate tensile strength by a factor described as the factor of safety.

The Deterministic design basis has not been used in the development of the NeSTS 132kV SC supports.

#### **3.2. Probabilistic design basis**

Consideration of the effects of random variability of loadings and weather conditions on the overhead line to ensure that risk of failure of each support component is acceptably low but using an assumption of a small probability of failure instead of using a factor of safety.

#### **3.3. Partial load factor**

Factor dependent on the selected reliability level, used to modify the calculated loads, taking into account the possibility of unfavourable deviations from the characteristic values of the loads, inaccurate modelling and uncertainties in the effects of the loads. [BS EN 50341-1 modified. Partial load factor on dead loads for ice loaded load conditions set to 1.0, refer to Table 10.]

#### **3.4. Partial strength factor**

Factor used to modify the mechanical strength of a component covering unfavourable deviations from the characteristic values of material properties, inaccuracies in applied conversion factors and uncertainties in geometric properties and the structural resistance model.

BS EN 50341-2-9:2017

#### **3.5. Reliability level**

Classification denoting the selected values for wind and ice actions corresponding to a theoretical time-period for return of those climatic actions.

[Reliability levels I, II and III correspond to returns periods 50, 150, and 500 years respectively. Lesser return periods and hence reliability are adopted for some temporary loading conditions and temporary construction.]

## **4. The Electricity Safety, Quality & Continuity Regulations 2002**

Overhead lines constructed using steel monopole supports in accordance with this PTS shall comply with the Electricity Safety, Quality & Continuity Regulations 2002, with either one or both circuits erected.

## **5. Historical background**

### **5.1. General**

The NeSTS 132kV SC specification has been developed as part of the Network Innovation Competition (NIC) project code SSEN03, to provide a steel pole solution to support of 132 kV overhead lines.

### **5.2. Design basis**

Historically, lattice steel tower designs in the United Kingdom have been based on either deterministic design principles or more recently probabilistic design principles, but the NeSTS 132kV SC supports are based only on probabilistic design principles. Probabilistic design principles correspond Approach 1 in both Part 1 and Part 2-9 of BS EN 50341.

## 6. Conductor system

### 6.1. Phase conductor and earthwire

The NeSTS 132kV SC design of supports permit the use of the conductor system as detailed in Table 1<sup>3</sup>.

**Table 1 - Conductor systems permitted on NeSTS 132kV SC supports**

Design reference	Phase conductor	Earthwire
NeSTS 132kV SC	1 x 185-AL4/ 43-ST6C Aluminium Alloy Conductor Steel reinforced (AACSR) - Pastel 288 @45°C	1 x 88-AL4/ 93-ST6C Aluminium Alloy Conductor Steel reinforced (AACSR) 2C OPGW- Phlox 181 <sup>1</sup>

For the assessment of the applied loadings, a conductor system equivalent to: 1 x Pastel 288 phase conductor and 1 x Phlox 181 earthwire has been adopted.

Where alternative conductor systems and span criteria etc., are used, the users of this PTS are responsible for ensuring that the quoted loadings etc., are applicable for their proposed application.

Users of this PTS should ensure that the basic meteorological parameters of the transmission line are in less onerous than those stated in Table 9. When the conditions are in excess of the values in Table 9, the users shall ensure the adequacy of the design.

### 6.2. Ultimate limit state sagging basis

The limit state sagging basis for the conductor system adopted for the assessment of the applied loadings is given in Table 2.

**Table 2 - Ultimate limit state sagging basis**

Conductor	Everyday tension		Maximum Erection Tension		Creep compensation (°C)
	Tension (kN)	Temperature (°C)	Tension (kN)	Temperature (°C)	
Pastel 288	30.3	5	45.4	-20	20
Phlox 181	32	5	48.1	-20	

Notes  
 [1] Earthwire tension to achieve sag match with Pastel 288 at 5°C  
 Conductor tensions under maximum working conditions shall not exceed nominal break load divided by partial materials factor (strength factor) = 1.25. NBL = 0.95 \* rated tensile strength. Refer to ENA TS 43-125, Pt 2, cl 2.3.5 for further guidance.

### 6.3. Conductor fittings

For details of the design, manufacture, installation and testing of the appropriate conductor's fittings for use with the conductor systems defined in Clause 6.1, reference should be made to the Project Specification.

Conductor fittings shall meet the requirements of BS EN 61284 and will only be type registered for use on conductor designs on which they have been tested.

<sup>3</sup> This PTS applies only to the single conductor system given in Table 1, however, it is envisaged that the use of other conductor systems will be justified in due course.

## 6.4. Partial strength factors for conductor system

In order to achieve the objectives of strength coordination as discussed in clause 11.12, the following partial strength factors are recommended

Component	Partial strength factor
Conductor	1.25
Insulators	1.6
Fittings	1.6

## 7. Internal and external clearances

### 7.1. General

Internal electrical clearances both within the span and at the support are based on the Part 1 Approach 1 requirements. Four distinct clearance checks are required, each under specific climatic conditions. Recommendations regarding the clearances to be used under these conditions have been taken from ENA TS 43-125, and reproduced in Table 3 for ease of reference.

**Table 3 – Minimum electrical clearances**

Nominal voltage	Loading case	Minimum clearance (m)			
		Within the span		At the support	
		cd - cd	cd – e/w	ph – ph	ph - ep
132 kV	Still air	1.35	1.21	1.35	1.22
	3-yr return wind	0.84	0.75	0.84	0.76
	50-yr return wind	0.41	0.28	0.41	0.28
	3-yr return ice	1.35	1.21	1.35	1.22

Legend: cd = conductor, e/w = earthwire, ph – ph = between phases or circuits, ph – ew = between phase conductor and earthed parts.

### 7.2. Internal clearances

Support types S2, S10, S30, and S60 meet the internal electrical clearances specified in Table 3, under the generic meteorological conditions outlined in Clause 10.4 of this Specification. The determination of the conductor or insulator set swing angles was based on the recommendations given in ENA TS 43-125, Pt 1, Annex 3.D.

The use of pilot sets, jumper weights and conductor stiffeners to achieve the specified at-support clearances is acceptable. Pilot-post insulators have been assumed for the assessments that have been made in the preparation of this PTS.

At-support clearances have been checked for the conductor system specified in table 1, in accordance with ENA TS 43-125.

### 7.3. External clearances

For details of the external in-span clearances to the ground or other obstacles reference should be made to ENA TS 43-8, Overhead Line Clearances.

#### 7.4. Downleads

The down-lead clearances quoted in Table 4 are based on the Part 1 ‘Empirical Approach’.

**Table 4 - Minimum down-lead clearances within span**

Nominal voltage	Loading case	Minimum clearance within span (cd-cd)(m)
132 kV	Still air	2.5 [1]
	3-year return wind speed	1.5 [2]
Notes cd-cd – spacing between conductors [1] At maximum continuous conductor temperature [2] The minimum 3-year return period wind speed conductor to conductor clearance should be achieved with the conductors of one phase subjected to the 3-year return period gust wind speed, while the conductors of the adjacent phase are subjected to the 3-year return period mean hourly wind speed.		

#### 7.5. Earthwire shade angle

The earthwire shade angle for NeSTS 132kV SC supports is 45 degrees from the vertical in still air.

#### 7.6. Phase to phase separation

Phase-to-phase separation ( $D_{pp}$ ) determines the reliability of the overhead line during switching overvoltages and is based on the minimum value of  $D_{pp}$  which will be maintained under the environmental conditions defined in BS EN 50341-2-9:2017, namely, high wind, combined wind and ice, and heavy ice.

For phase-to-phase in-span clearances, the adopted value of gap factor  $K_g$  is 1.6 [ENA TS 43-125]. The minimum electrical clearances have been calculated in accordance with IEC 60071-1 and 60071-2.

## 8. Insulators and insulator sets

### 8.1. General

For details of phase conductor and earthwire attachment points, reference should be made to the appropriate general arrangement drawings.

### 8.2. Suspension insulator sets

For details of the suspension insulator sets that are suitable for use with the NeSTS 132kV SC supports reference should be made to drawing **TBC by TA once set is selected**.

The nominal length of the insulator set assumed for the design studies for Pastel 288 is 2030mm. The nominal tension capacity for suspension insulators is 125kN.

Clearance studies have been based on composite insulator units, however, this does not preclude the use of glass or porcelain strings if required. The use of weighted suspension sets may be required above an altitude of 500m.

### 8.3. Tension insulator sets

For details of the tension insulator sets that are suitable for use with the NeSTS 132kV SC supports reference should be made to drawing **TBC by TA once set is selected**.

The nominal lengths of insulators assumed for the design studies for single Pastel 288 is 2661mm. The nominal tension capacity of tension insulators is 190kN.

### 8.4. Pilot post insulator sets

For details of the pilot post insulator sets that are suitable for use with the NeSTS 132kV SC supports and intended for the outside angle of the S30 and S60 supports, reference should be made to drawing **TBC by TA once set is selected**.

The nominal lengths of insulators assumed for the design studies for single Pastel 288 is 1650mm. The Maximum Design Cantilever Load (MDCL) for the insulator is **TBC**.

### 8.5. Low duty tension insulator sets

For details of low duty insulator sets that are suitable for use with the NeSTS 132kV SC supports reference should be made to drawing, **TBC by TA once set is selected**.

The nominal lengths of low duty tension sets assumed in the design studies for single Araucaria and twin Totara are **[TBC]** mm and **[TBC]** mm respectively.

### 8.6. Earthwire sets

For details of OPGW earthwire suspension sets and tension sets that are suitable for use with the NeSTS 132kV SC supports reference should be made to drawings:

- [Annex **TBC**], OPGW suspension set
- [Annex **TBC**] OPGW tension set

The nominal length for the earthwire suspension set assumed for the design studies is 355 mm **[TBC]**.

## 9. Supports

### 9.1. General

A complete range of steel pole supports has been designed, including S2, S10, S30, S60, ST and Cable Transition Support [TBC].

At the time of drafting, full scale testing of the S2 and S30 supports is proposed.

### 9.2. Types and uses

The range of standard support types available is shown in Table 5 (general arrangement drawings can be found in Annex E), together with their respective angles of deviation and or angles of entry. Each of these support types has been designed so that the support heights may be altered by the extensions or reductions defined in clause 9.3 of this PTS.

**Table 5 – Support Suite – Angles of deviation**

Code	Description	Deviation (°)
S2	Suspension	0-2
S10	10° Angle	0-10
S30	30° Angle	10-30
S60	60° Angle	30-60
ST	Terminal	0-5 (entry)
TBC	Cable Transition	TBC

S10 supports may be used in straight in line positions where it is necessary to arrange for sectioning and tensioning of the phase conductors and earthwire in a straight run of a line route.

All angle supports are suitable for zero weight spans combined with maximum wind spans throughout the full ranges of line deviations for which the angle supports are designed.

### 9.3. Extensions

Details of the extensions and reductions available for the standard types of support are given in Table 6 (the range is also presented in the key diagrams in Annex F).

An extension to the standard height tower is designated by the letter 'E' followed by the height of the extension in metres. A reduction to the standard height is designated by the letter 'M' followed by the height of the reduction in metres.

**Table 6 – Support Suite – Range of extensions**

Code	Range of normal extensions and reductions to standard height
S2	M6 – E12 (in 2.0m increments)
S10	M6 – E12 (in 2.0m increments)
S30	M6 – E12 (in 2.0m increments)
S60	M6 – E12 (in 2.0m increments)
ST	M6 – E12 (in 2.0m increments)
Cable Transition	TBC

### 9.4. Spigot connections to foundations

For each support, the connection between steel pole and foundation is via a truncated reinforced concrete cone, sized to achieve a 1.5 x diameter insertion into the bottom section of steel pole, and formed using permanent steel shuttering. The truncated cone is referred to in this PTS as a spigot; other specifications and design guides refer to spigots by other terms including immured foundations, dowel foundations and foundation pins.



The initial verticality of the axis of each spigot is critical to the overall verticality of the support. Depending on the type of support and the proposed angle of deviation, there may be a requirement to set at a rake the axis of the spigot during construction, to achieve optimised verticality of the support in everyday conditions, and to suit site-specific construction sequencing.

Spigots are constructed with a diameter and a taper to match that of the bottom of the pole, and at a level that results in the bottom of the pole resting at nominally 500 mm above ground level.

## **9.5. Base plate with holding down bolts**

'Base plate with holding down bolt' connections (BPHD) can be used to secure steel poles to concrete foundations instead of the spigot connections referred to in clause 9.4. BPHD connections are to be designed in accordance with BS EN 50341-1, Section 7.4.

The base plate and the holding-down bolts shall be adequate to take the applied loads developed at the joint between the structure and the foundation.

Holding-down bolts are to be designed to transmit the shear load. The holding-down bolt / base flange connection detail is to be designed to achieve good drainage and ventilation at the base of the poles.

## **9.6. Ancillary support fittings**

### **9.6.1 Access Facilities**

One access ladder is provided to each support located, on plan, central on the transverse face of the pole. The ladders comprise a central rail with alternate step bolts, extending from a notional plane 3.0 m above ground level to the top of the pole. The ladder is split into sections and secured to the pole via bolted cleats such that nominal slippage in slip-joints is accommodated.

One  $\frac{1}{4}$  access ring is positioned at the start of the access ladder to allow a ladder hook to be positioned to provide access to the pole. Two partial access rings are provided at each crossarm level, to allow access to the crossarm connection bolts and armpit rigging points. Full rings are provided at the earthwire peak to allow for a range of working positions when working on the earthwire.

Provision of an anti-slip surface finish on the top side of the crossarms is also to be provided to enhance access safety during wet conditions.

### **9.6.2 Anti-climbing devices**

An assessment of the risk of climbing has been undertaken with reference to ENA TS 43-90. The smooth, near vertical sides of the bottom sections of poles deters climbing. No additional anti-climbing devices are detailed for standard installations.

### **9.6.3 Safety signs and identification plates**

Provisions have been made for attachment of safety signs and identification plates to the supports in accordance with the requirements of ENA TS 43-90.

### **9.6.4 Livestock guards**

The smooth, near vertical sides of the bottom sections of poles is not considered hazardous to livestock; no livestock guards are detailed for standard installations.

### **9.6.5 Earthwire bonding**

To facilitate the attachment of flexible earthwire bonds to the support, a cleat with a 17.5 mm hole is provided on each pole adjacent to the earthwire attachment points.

### **9.6.6 Earthing of supports**

To facilitate connection of earth electrodes to the pole body, welded cleats with 17.5 mm diameter holes have been provided close to ground level. This provision is to be provided in the bottom section of pole at each site.

### **9.7. Design life**

The NeSTS supports are to be designed and constructed to have a minimum design life of 80 years. The supports will require limited maintenance; the period to first maintenance is to exceed 20 years.

## **10. Design basis, actions and reliability**

### **10.1. General**

For the assessment of applied support loadings, a generic set of reliability levels, corresponding partial load factors, span criteria and basic meteorological parameters have been adopted. Based on these parameters, a generic set of climatic, 'construction and maintenance' and accidental actions have been derived as outlined in the following clauses.

The actual actions considered for the design of specific support types are given in the design load schedules in Annex B. The loads stated are an indication of the upper boundary limits which the supports will safely withstand. Other conductor systems, span criteria, meteorological parameters, e.g. higher winds with reduced radial ice thicknesses, may be proved satisfactory provided that the effects of these boundary loads are not exceeded. However, the users of this PTS are responsible for ensuring that the quoted loadings and partial load factors etc., are applicable for their proposed application.

## 10.2. Reliability levels and partial load factors

The reliability levels and associated partial load factors adopted for the generic tower loadings are shown in Table 7.

- For suspension supports designed for use in open country reliability level 2 has been adopted.
- For suspension supports constructed in areas adjacent to habitation, or at critical crossings, i.e. critical suspension supports, reliability level 3 has been adopted, and
- For tension and terminal supports, reliability level 3 has been adopted.

**Table 7 - Reliability levels and partial load factors**

Action (load)	Application	Partial load factor	
<b>Variable actions</b>			
Climatic loads		<b>RL 2</b>	<b>RL 3</b>
(1a) High wind	$\gamma_v$ on wind speed	1.1	1.2
(2a) Heavy ice	$\gamma_v$ on ice thickness $r_o$	1.1	1.2
(3a) Combined wind and ice	$\gamma_v$ on ice thickness $r_w$ , and wind speed [1]	1.1	1.2
<b>Safety loads (construction and maintenance loads)</b>			
Active conductor tension	$\gamma_L$	2.0	
Landed conductor tension	$\gamma_L$	1.5	
Construction loads [2]	$\gamma_L$	1.5	
<b>Permanent actions</b>			
Self-weight [3]	$\gamma_{DL}$	0.9 or 1.1	
Self-weight for calculation of conductor tensions	$\gamma_{DL}$	1.0	
<b>Accidental actions – security loads</b>			
Conductor tensions [4]		1.0	
Climatic loading [5]	$\gamma_v$ on ice thickness $r_w$ , and wind speed [1]	0.75	0.75
Notes			
[1] Factor B1 = 0.68 also applied to wind speed for 3a loading			
[2] Applied to access platforms, weight of linesmen etc.			
[3] Select value which causes most onerous effects			
[4] Unbalanced conductor tensions in broken wire conditions			
RL = Reliability level as defined in Part 2-9			

### 10.3. Span criteria

For the assessment of applied support loadings, the generic span criteria adopted for use with Pastel 288 conductor and Phlox 181 earthwire, is shown in Table 8. Due to the high altitude application of the design on some routes a range of three altitude bands have been considered which each have their associated span criteria. The span criterion are applicable to support types S2, S10, S30, S60 and ST, and for extension ranges M6 – E12.

**Table 8 - Span criteria**

Criteria	Value 0-250m	Value 250-500m	Value 500-750m
Standard span	300	210	160
Maximum sum of adjacent spans	630	510	390
Maximum single span	450	325	250
Maximum weight span	500	435	330
Minimum weight span, S2 suspension supports	221	150	115
Minimum weight span, tension supports	0	0	0
Notes			
<ol style="list-style-type: none"> <li>1. Maximum and minimum weight-spans, conductor self-weight only, at -10°C</li> <li>2. All span criteria given in metres (m)</li> <li>3. Weight-spans less than zero may be permitted, subject to the additional checks set out in clause 11.13</li> </ol>			

For suspension supports, the maximum sum of adjacent spans, and hence wind-spans, have been based on an angle of deviation of 2 degrees; at sites where the AOD is zero, the wind-span may be increased, subject to site specific verification of support reliability.

### 10.4. Basic meteorological parameters

The basic meteorological parameters and associated coefficients considered in the assessment of the applied support loadings are given in Table 9

**Table 9 - Meteorological parameters**

Parameter	Value
Basic 10 minute mean wind speed $v_{b,map}$ (m/s)	27 m/s
Radial ice thickness without wind, $r_o$ (mm)	76mm
Radial ice thickness with wind, $r_w$ (mm)	26mm
Terrain roughness category [1]	II
Wind direction factor $C_{dir}$ [2]	1.0
Combined wind and ice factor B1 [3]	0.64
Number of wires $N_c$ adopted for calculation of shape factor $K_c$ [4]	4
Maximum altitude above ordnance datum (m)	750m
<b>Notes</b>	
[1] Terrain roughness category II: Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 times obstacle heights	
[2] In the assessment of applied support loading the value of $C_{dir}$ in the table above was adopted. Site specific values may be adopted for site specific checks.	
[3] The use of factor B1 is explained in Part 2-9, it reduces the wind speed that is considered in conjunction with ice thickness $r_w$	
[4] $N_c = 4$ for single circuit configuration	
[5] Orography factor has been taken as 1, the orography factor is to be considered by the designer on a site specific basis as per Part 2-9.	

## 10.5. Climatic loadings

The following standard climatic loading cases have been considered in the assessment of the applied support loadings.

- Case 1a – Extreme wind at 0°C
- Case 2a – Heavy uniform ice accretion on all spans at -10°C, with unit weight of ice 5.0 kN/m<sup>3</sup>
- Case 3a – Combined wind and ice, uniform glaze ice on all spans at -10°C, with unit weight of ice 9.0 kN/m<sup>3</sup>

Single circuit strung (SCT) has been considered in the derivation of design loads. Reference should be made to design load schedules listed in clause 10.1 for details of the specific generic climatic loadings that were adopted for the design of individual support types.

## 10.6. Construction and maintenance loadings

The following generic construction and maintenance (C&M) loading conditions have been considered in the assessment of the support loadings.

- Case 4a – Suspension supports – ‘catch-off’ of phase conductors under still air conditions
- Case 4b – Tension supports – conductor erection or lowering, pulling along the line, still air conditions
- Case 4c – Tension supports – conductor erection or lowering, square-rigged, still air conditions
- Case 4d – Tension supports – earthwire erection or lowering, square-rigged, still air conditions

For loadcases 4a – 4c, a load factor of 1.5 has been applied to conductor tension and to vertical loads arising from landed conductors; a factor of 2.0 has been applied to active conductor tensions, to vertical loads arising from active conductors, and to attached equipment.

The C&M loading conditions have been based on procedures set out in National Grid Linesman’s Manual M1. In addition to conductor and earthwire tensions, allowance has been made for attachment of an access platform and for linesmen access on crossarms supporting active conductors and earthwires; for further details refer to design note 90SS686-DN-016.

In accordance with EN 50341-1, clause 4.9, an allowance of 1.0 kN has been included in the derivation of C&M loading where linesmen may require access. A load factor of 1.50 has been applied, which results in a design load of 1.5 kN for each linesman. It has been assumed that two linesmen may be working together at the end of a crossarm that is supporting an ‘active’ conductor.

It has been assumed that an access platform may be attached to the ends of tension support crossarms during C&M activities, on ‘active’ conductors. A characteristic weight of 5.85 kN has been adopted in the assessment of C&M loading scenarios.

C&M loading scenarios have been considered in the design of the NeSTS supports, however, the users of this Specification must ensure that the derived loadings together with any associated limitations are adequate for their own particular application.

## 10.7. Accidental actions – security loadings

The following generic security loading cases have been considered in the reassessment of the applied tower loadings.

- Case 5a – Suspension towers – one broken wire, conductor or earthwire, in still are at 5°C, with a tension reduction factor ( $\beta$ ) of 0.7
- Case 5a1 – tension towers – one broken wire, conductor or earthwire, in still are at 5°C, with a tension reduction factor ( $\beta$ ) of 1.0
- Case 5b tension towers - one broken wire, conductor or earthwire, in 3-year return period combined wind and ice conditions at -10 °C.

## 10.8. Permanent actions

For the assessment of applied loading on the supports due to the self-weight of insulators, and the self-weight of the components of the support the partial load factors shown in Table 10 have been adopted in the derivation of the design loads.

In the calculation of conductor tension, a dead load factor of 1.0 has been adopted.

**Table 10 - Permanent loadings partial load factors**

Case	Condition	Partial dead load factor ( $\gamma_{DL}$ )		
		Max Wt Span	Min Wt span	Support
1a	High wind	1.1	0.9	1.1 or 0.9
2a	Heavy ice	1.0	1.0	
3a	W&I	1.0	1.0	
4a – 4d	C&M	1.5/2.0 [1]	N/A	
5a and 5a1	Broken wire – still air	1.1	0.9	
5a2	Broken wire – W&I	1.0	1.0	
Notes				
C&M – Construction and maintenance loading conditions				
W&I – Combined wind and ice loading				
[1] 1.5 applied to landed wires, 2.0 applied to active wires				

## 10.9. Supplementary actions

### 10.9.1 Insulator set wind areas

The following insulator set wind areas have been considered in the assessment of the support loadings:

Suspension insulator set	1 x 1.0 [TBC] m <sup>2</sup>
Tension insulator set	1 x 1.0 [TBC] m <sup>2</sup>
Post insulator (on tension support crossarms)	1 x [TBC] m <sup>2</sup>

### 10.9.2 Insulator set self-weight

The following vertical loading due to the self-weight of the insulator sets have been considered in the assessment of the support loadings:

Suspension insulator set	1 x 0.5 [TBC] kN
Tension insulator set	1 x 0.6 [TBC] kN
Post insulator (on tension support crossarms)	1 x [TBC] kN

### 10.9.3 Down-leads

The following down-lead loadings have been considered in the reassessment of the tower loadings:

- Maximum limit state tension in down-leads per phase [TBC] to substation structures
- Assumed vertical loadings at support when [TBC] down-leads are deemed to be horizontal
- Maximum limit state tension in down-leads per phase [TBC] to anchor blocks

To ensure a consistency in approach partial load factors of 1.21 and 1.44 have been applied to the limit state down-lead tension for reliability levels 2 and 3 respectively.

Site-specific loading checks are to be undertaken for terminal supports.

### 10.9.4 Site specific load checks

For loading conditions or support types and extensions that are outside those considered herein, the users of this PTS are responsible for undertaking their own generic or site-specific loading checks.

## 11. Analysis and design of supports

### 11.1. Partial strength factors

For the analysis of the supports, the partial strength factors shown in Table 11 have been adopted.

**Table 11 - Partial strength factors for supports**

Material/element property	Partial strength factor ( $\gamma_m$ )
Resistance of crossarm hollow sections	1.1
Resistance of principal pole	1.1
Resistance of net-section at bolt holes	1.25
Resistance of bolts in shear or bearing	1.25
Resistance of bolts in tension	1.25
Resistance of welded connections	1.25

### 11.2. Wind loading on supports

The wind loading on supports has been assessed in accordance with Part 1, clause 4.4.4, and Part 2-9.

Detailed pole loading data has been derived by splitting the pole into sections, the top and bottom of each section corresponding to nodes, and to top and bottom levels of splice connection overlaps.

### 11.3. Support self-weight

In calculating the self-weight of the supports, the self-weight of the principal components have been taken into account, including the principal pole and splice overlaps, crossarms, and stays; no allowance has been included for vang-plates, end-plates, attachment plates, climbing rails, bolts etc.

In determining the weight of ice on the supports, the thickness of ice on principal members has been calculated in accordance with Part 2-9, with  $K_c = 1.0$ .

### 11.4. Tension supports - applied load distribution

Out of balance loading has been considered in the derivation of design loads. The proportions of vertical load applied to the back span attachments and the ahead span attachments follow from the span differentials arising from maximum sum of adjacent spans, maximum single span and maximum weight span. Typically, the ratio of back span to ahead span equals the ratio of vertical vector load components in the back span and the ahead span.



## 11.5. Design stresses

Designs of steelwork complies with BS EN 1993-1 and the standards referenced therein. The design strengths adopted in the design of the supports are stated in Table 12 for ease of reference. Steel grade S460 may be utilised to manufacture pole sections which do not connect to cross arms.

**Table 12 - Design stresses adopted in the design of the supports**

Material	Yield strength (N/mm <sup>2</sup> )	Ultimate strength (N/mm <sup>2</sup> )
Steel grade S275 (< 16mm)	275	410
Steel grade S275 (< 40mm)	265	410
Steel grade S275 (< 63mm)	255	410
Steel grade S355 (< 16mm)	355	470
Steel grade S355 (< 40mm)	345	470
Steel grade S355 (< 63mm)	335	470
Steel grade S460 (< 16mm)	460	540
Steel grade S460 (< 40mm)	440	540
Bolts grade Gr 8.8	640	800
Bolts grade Gr 10.5	900	1000

## 11.6. Member and connection design

Strength checks on tubular members, including principal poles and crossarms have been made in accordance with ASCE 48-11, using PLS Pole software.

The design and location of connections between support elements, between element sections and between supports and foundations, takes into consideration assembly, erection, maintenance and dismantling operations, assuring safe systems of work at all times.

Generic strength checks on crossarm connections and stay connection have been carried out in accordance with BS EN 1993-1-8, Design of steel structures - Design of joints. The principles of the connection designs illustrated by the general arrangement drawings have been verified by calculation and by full scale testing.

Connections are to be justified by calculations, to have sufficient capacity to withstand the design actions and effects of actions. The design actions and effects of actions are given in Annex C.1. [TBC] Connection designs that differ in principle to the generic connection designs are also to be justified by calculations, but also by full scale testing. The use of finite element analysis (FEA) software (such as ANSYS) to model the connection designs, in particular the crossarm to pole connection, are required to justify the design.

Connections between crossarms and principle poles, between stays and principal poles and between stays and crossarms are to be bolted, to facilitate construction and dismantlement.

Connections within the height of principal poles are to be slip-joint connections, designed in accordance with ASCE 48-11.

*Slip-joints shall be designed to resist the maximum forces and moments at the connection. Taper above and below the slip joint shall be the same. To develop the ultimate capacity of the section, the joint shall have a minimum lap length of 1.5 times the maximum inside diameter across the flats of the outer section (nominal to be dictated by manufacturing tolerances to ensure the minimum).*

### 11.7. Support analysis

The analysis of the specific support types was undertaken using the 'PLS-Pole version 15.00' computer program, developed by Power Line Systems Inc. 'PLS-Pole' three-dimensional finite element models of the supports were analysed using nonlinear elastic techniques.

### 11.8. Limitations on deflections

The supports have been assessed when subject to the specified design loading scenarios. Pole top deflections do not exceed the limits stated here.

Loading scenario	Return period	Pole to deflection limit (x top diam)
High wind	50-year	2
	3-year	1
Heavy ice	50-year	2
	3-year	1
Combined wind & ice	50-year	2
	3-year	1

In addition, the pole top deflection for each support does not exceed 8% of the above ground height of the support in compliance with the recommendation of Part 1, calculated using second order analysis under ultimate limit state conditions.

The rotation of foundations, starting from the permanent position at EDT through to the position during ultimate loading conditions, shall not exceed 1 degree. Foundations are to be designed to achieve this limit.

The verticality of the axis of each foundation is to be set during construction to result in the centre of the pole top being directly above the pole at ground level in the permanent condition, i.e. at EDT.

### 11.9. Limitations on mass and size of components

The mass and dimensions of sections of individual support elements have been carefully considered in the development of the NeSTS 132kV SC supports, so as to allow for practical, safe and economic; fabrication, transport, assembly, erection, maintenance and dismantlement. The dimensions and weights of components shall not exceed the criteria set out here, without justification and approval.

Maximum length of component	13.6 m (transport and galvanising constraints)
Maximum width of component	2.8 m (galvanising limit)
Maximum mass	15 tonne (galvanising limit)

Further restrictions may apply corresponding to combinations of dimension and mass limits.

### 11.10. Corrosion protection

The internal and external surfaces of all components are to be protected by galvanising in satisfaction of ASTM A123/A123M-17 and BS EN 1461:2009 with a minimum required mean coating thickness of zinc of 0.11mm.

Where hot dip galvanisation is impractical, pole components that do not connect to cross arms may be metallised, subject to the following conditions;

1. Metallised components and assemblies shall be designed to conform to BS EN ISO 2063-1:2019
2. Metallised components and assemblies shall be metallised in accordance with BS EN ISO 2063-2:2017
3. Metallisation shall comprise ZnAl15 of minimum thickness 0.2mm as sprayed.

- a. Metallisation comprising Zn99.99 of minimum thickness 0.15mm as sprayed may be considered if ZnAl15 is unavailable on a case by case basis. In this event, confirmation of acceptance in writing from SSEN must be evidenced.

4. Metallised coatings shall be sealed in accordance with BS EN ISO 2063-2:2017.

Further protection is to be provided to external faces to result in an approved duplex system. Systems should be approved by the client on a case by case basis, however paint systems complying to BS EN ISO 12944, including PUR systems, and 80um P2.2 powder coating systems complying with DIN 55633 are considered suitable.

Alternative corrosion protection systems may be considered, however, all corrosion protection systems must be suited to achievement of the specified overall design life, the specified time to first maintenance, operational requirements and environmental requirements.

The specification and colour of finish coatings are to be approved and they are to take into account all of the environmental objectives. The paint coating will be applied at the point of manufacture, therefore preventing the need for painting on site.

#### 11.11. Limitations on use of this document

This PTS is in a preliminary stage of development, it should not be used as a basis for overhead line design without further development, including testing of supports.

This PTS does not extend to consideration of

- Interface with existing OHL designs and configurations
- Special crossing arrangements e.g. large watercourses.
- Tension supports which have an uplift condition on crossarms

#### 11.12. Strength coordination

With reference to Part 1, Annex A, strength coordination has been considered in the development of the NeSTS supports. The partial factors given in Table 7 and Table 11 result in achievement of the strength coordination outlined in Table 13.

**Table 13 - Strength coordination**

	Major Components	Coordination within Major Components *
Lowest strength	Suspension support	<u>Support</u> , foundations, hardware
	Tension support	<u>Support</u> , foundations, hardware
Not having the lowest strength	Terminal support	<u>Support</u> , foundations, hardware
	Conductor system	<u>Conductors</u> , insulators, hardware

#### 11.13. Limitations on net uplift loading for tension supports

Where uplifting loading is predicted for any design condition, site specific checks are required. 'Design conditions' include all construction conditions, all maintenance conditions, all security conditions, and all climatic weather conditions.

For design conditions, the net vertical component of actions from the front and back spans shall not exceed the uplift limits stated in Table 14.

**Table 14 - Limits on net uplift loading**

NeSTS Type	Uplift limit (kN)
S10	35.0
S30	37.0
S60	37.0
ST	32.0

The moment arising from the net factored uplift load shall not exceed the vertical moment capacity of the crossarm to pole connection.

Considering each slip-joint individually, the total net uplift imposed by conductors above the slip-joint shall not be greater than half of the dead-weight of the structure above, unless uplift restraint straps are fitted. Where required, uplift restraint straps shall be designed to resist a force equal to the total design uplift force from all conductors and the earthwire, less half of the deadweight of the support above the slip-joint.

Stays are to be installed with a nominal tension of 2% ultimate tension capacity, before stringing. For sites where uplift is expected at EDT, either in the front or back spans, or both, the stays shall be re-tensioned after stringing, to at least 2% ultimate tension.

## **12. Foundations**

### **12.1. Foundation loads**

Global applied foundation loads inclusive of the partial load factors, are given in Annex C for the support types and extensions considered. Only minimum and maximum height extensions have been considered. The users of this PTS are responsible for determining their own foundation loading, if the generic loading criteria, support types and/or extensions are not met and under any temporary and/or construction - maintenance loading conditions.

### **12.2. Partial strength factor for foundations**

A minimum partial strength factor of 1.35 shall be adopted in the design of foundations. Generally, the strength factors that are adopted for the design of foundations shall be in accordance with BS EN 1997 and the associated NNA.

### **12.3. Design standards for foundations and spigot connections**

Foundations are to be designed in accordance with BS EN 1997-1, Geotechnical Design.

Reinforced concrete components, including spigots, pile-caps, rafts etc. are to be designed in accordance with BS EN 1992-1.

## **Bibliography**

### **Standards publications**

BS EN 1990  
Eurocode – Basis of structural design

BS EN 1992 and NNAs to BS EN 1992  
Design of concrete structures

BS EN 1993 and NNAs to BS EN 1993  
Design of steel structures

BS EN 1997 and NNAs to BS EN 1997  
Geotechnical design

BS EN 10025  
Hot rolled products of structural steels

BS EN 50341-1:2012  
Overhead electrical lines exceeding AC 1 kV.  
General requirements. Common specifications

BS EN 50341-2-9:2017  
Overhead electrical lines exceeding AC 1 kV.  
National Normative Aspects (NNA) for Great Britain and Northern Ireland

ASCE 48-11: 2012  
Design of Steel Transmission Pole Structures

### **Other publications**

BS EN 60071-2:1997  
Insulation co-ordination – Application guide

BS EN 60652:2004  
Loading tests on overhead line structures

BS EN 62305-2:2012  
Protection against lightning – Risk management

BS EN 61773  
Overhead lines – Testing of foundations for structures

Cigre TB 048  
Tower top geometry

Cigre TB 063  
Guide to procedures for estimating the lightning performance of transmission lines.

Cigre TB 151  
Guidelines for Insulation Coordination in Live Working

Cigre TB 348  
Tower Top Geometry and Mid Span Clearances

Cigre Green Book  
Overhead lines, Study committee B2, ISBN : #3319317466

ENA TS 43-90

Anti-climbing devices and safety signs for HV lines up to and including 400 kV

ENA TS 43-125 Issue 2:2017

Design guide and technical specification for overhead lines above 45kV

IEC 60826

Overhead transmission lines - Design criteria

NG TGN(E) 026

Current ratings for overhead lines

NG TS 1

Ratings and requirements for plant, equipment and apparatus

NG UL/PL/ETSR/GN

National Grid Safety Rules and Guidance

NG National Grid Company Linesman's Manual M1,

132 kV, 275 kV and 400 kV Overhead lines, ('Dead Line' Working)

NSI 04

Work on or near high voltage overhead lines [NGUK/PM/ETSR/NSI/04/GN Issue 5]

SSEN Operational Safety Rules (2012)

SSEN PR-PS-340

Application of Clearances to Overhead Lines at LV to 400 kV

SSEN PR-PS-580

Approved Procedure for the Fitting and Removal of Additional Earths on 66, 132, 275 & 400kV Overhead Lines

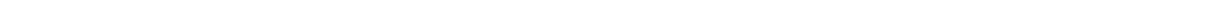
Statutory Instruments No 2665 (UK)

Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR)



## **ANNEX A – General information for the assessment of probabilistic design loadings**

The contents of this annex are intentionally blank, tables to be confirmed.





## **ANNEX B – Probabilistic design loadings**

90SS686-95-023-Issue 3

90SS686-95-024-Issue 3

90SS686-95-025-Issue 3

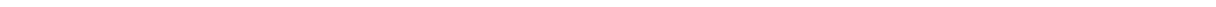
90SS686-95-026-Issue 3

90SS686-95-027-Issue 3



# **ANNEX C – Applied foundation loads**

90SS686-95-030-Issue 1



## **ANNEX D – Design forces and effects of forces for connection design**

The contents of this annex are intentionally blank, tables to be confirmed.



## **ANNEX E – General Arrangement Drawings**

90SS686-132-S2-012 - Issue 4

90SS686-132-S10-012 - Issue 2

90SS686-132-S30-012 – Issue 3

90SS686-132-S60-012 – Issue 2

90SS686-132-ST-012 – Issue 2



## **ANNEX F – Key Diagrams**

90SS686-132-S2-002 - Issue 4

90SS686-132-S10-002 - Issue 2

90SS686-132-S30-002 – Issue 2

90SS686-132-S60-002 – Issue 2

90SS686-132-ST-002 – Issue 2



# ANNEX G – Manufacturing Tolerances

## 1. General

Tolerances in fabrication and erection shall ensure compliance with clearance, appearance, strength and assembly requirements.

## 2. Interchangeability

Sections and components of one structure shall fit and be interchangeable with all other structures of the same type and height.

## 3. Slip-joints

At slip-joints, the sum of the lengths of gaps between male and female parts that exceed 3mm shall not exceed 30% of the slip-joint circumference (length of flats). Also, any gap that extends across two adjacent flats, shall not exceed 6mm at any point.

## 4. Independence of Tolerances

Tolerances are independent. No individual tolerance can be met through combination of multiple specified, referenced, or implied tolerances.

## 5. Table of Tolerances

### Tolerances for NeSTS 132 Single Circuit Supports

	Max tolerance	Min tolerance	Other tolerance
<b>Overall geometry</b>			
Overall length of support (assembled)	+25.0 mm	-25.0 mm	for slip-jointed structures, +150mm per slip-joint
Spacing between crossarms at pole	+25.0 mm	0 mm	
Offset of attachment point (xarm length)	+25.0 mm	0 mm	
Slope of crossarms	+0.5 deg	-0.5 deg	
Vertical alignment of crossarms			0.167 degrees/m
Twist in structure after sleeving			3 degrees
Straightness			2 in 1000
<b>Tubes</b>			
Flat to flat, diameter,	+20.0 mm/m	0 mm	
Length of tube	+25.0 mm	-25.0 mm	
Ovality	+1% diameter	-1% diameter	
<b>Slip-joints</b>			
Minimum length of slip-joint overlap	+10% of design length	0 mm	
Inside diameter of inside piece of fitting pieces	+ 5.0 mm	0 mm	
Outside diameter of fitting piece	0 mm	-2.0 mm	
<b>Base plates (where fitted)</b>			
Plan diamentions	+ 25.0 mm	- 6.0 mm	
Pole eccentricity	+ 5.0 mm	- 5.0 mm	
Spacing between HD bolts	+1.5 mm	-1.5 mm	
Squareness to pole CL	+ 3.0 mm	- 3.0 mm	
Flatness, deviation from flat	+ 5.0 mm	- 5.0 mm	
<b>Other</b>			
Thickness of steel			BS EN 10029, Class C
Length and widths of plates	+ 2.0 mm	- 2.0 mm	
Location of non-mating pieces on a weldment	+ 3.0 mm	- 3.0 mm	
Deviation from flat of flat plates	+ 3.0 mm	- 3.0 mm	
Deviation from flat of mating surfaces	+1.5 mm	-1.5 mm	
Location of a drilled hole in a piece	+ 3.0 mm	- 3.0 mm	
Centres of holes (within group)	+ 1.0 mm	- 1.0 mm	
Centres of holes (between groups)	+ 2.0 mm	- 2.0 mm	
bolt hole diameter (after galvanising)	+ 1.5 mm	0 mm	
Hardware locations relative to top of support	+50.0 mm	-50.0 mm	